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Ecological Studies on Wolf Spiders (Araneae: Lycosidae) in a Northwest Area of Kanto Plain, Central Japan: Habitat Preference Observed by Hand-sorting

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藤井靖浩[1)]：関東平野北西部におけるコモリグモ類（クモ目：コモリグモ科）の生態学的研究：ハンドソーティングで調査された生活場所選好性

Abstract Wolf spiders (Araneae: Lycosidae) of 19 species were collected by hand-sorting in a northwest area of Kanto Plain, Japan, and their habitat preferences were inferred from their frequency in 10 habitats classified by three environmental elements (substrata, light, water). In addition to the 12 species surveyed by trapping (Fujii 1997), the hand-sorting enabled to examine the other seven species, *Alopecosa virgata*, *Arctosa depectinata*, *A. subamylacea*, *Lycosa coelestis*, *Pardosa pseudoannulata*, *P. yaginumai*, and *Pirata subpiraticus*, and to know more accurate preference of *Pardosa agraria*, *P. astrigera*, *Pirata clercki*, and *P. piratoides*. The interspecific differences were large within each genus, but were not found between *Arctosa ebicha* and *A. fujiii* and between *Pirata procurvus* and *P. tanakai*. Partial overlap was also detected among the preferences of other several *Pardosa* or *Pirata* species. The differences among the developmental stages were not obvious.

Introduction

Most wolf spiders (Araneae: Lycosidae) are common hunters wandering near the ground surface. I found large interspecific variations in maternal care (Fujii 1976) and life cycles among 19 lycosid species dwelling in a northwest area (35°54′N, 139°23′E) of Kanto Plain, central Japan. It seems that these variations had differentiated correspondingly to environmental conditions or their stability of each lycosid habitat. As little was known for habitats and life cycles in these lycosids, I collected them by pitfall-trapping and hand-sorting from 1981 to 1987, and examined their frequency in various habitats and seasonal changes in body size or developmental stages. For comparison of habitat preferences, lycosid habitats were classified by qualities or grades in three environmental elements, substratum, light condition, and water condition. The trapping was effective in forests and tussocks but not in open habitats, and was inapplicable especially to low-mobile species in wet land (Fujii 1997). In contrast, hand-sorting was applicable to most habitats except dense tussocks and also to low-mobile species or stages. The

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present paper shows the frequencies of all the 19 species collected by the hand-sorting, then discusses their habitat preferences inferred from both the trapping and hand-sorting and differences in stability or mildness of environmental conditions among the habitat classes.

Sampling Sites

Sampling by hand-sorting was carried out at 28 sites of Subarea A〜E (Fig. 1c). Fifteen sites were located in subareas on a northern flat plateau (Figs. 1a, 1c), and the other 13 sites were located in Subarea B (Figs. 1b, 1c) in a southern lowland with a shallow pebbly river (Koaze-gawa R.), a small spring, and paddy fields. Habitats of these sites were classified into any one of the 12 classes (Table 1). There was no site for hand-sorting in classes of *Dd1* and *Dd2*.

Characteristics of the sampling sites except those already described in Fujii (1997) were as follows.

[Ab1, Cb, Eb, Bk2] Sunny bare ground. Ab1 and Eb, cropland; Cb, an athletic field; Bk2, an edge of a pond artificially isolated from the river at the end of 1983. The soil was sandy, clayey, and pebbly, respectively. Bk2 was reclaimed in the autumn of 1984.

[Ab2, Bk3, B1, Bm2, Bn, Bk15, Bm1] Meadows with poor litter. Ab2, a fallow upland field contiguous to Ab1; Bk3, a riverbank ridge; B1 and Bn, fallow paddy fields; Bm2, a levee of a paddy field; Bk15 and Bml, 0.5〜1 m-wide zones along the river and an irrigation ditch, respectively. The soil was sandy at Ab2, pebbly at Bk15, and clayey at the others. That of B1 and Bn was covered with standing water from May to September.

[Ca, Ec, Bk13, Dm] Sunny ground with thick litter. Ca and Ec, forest edges; Bk13

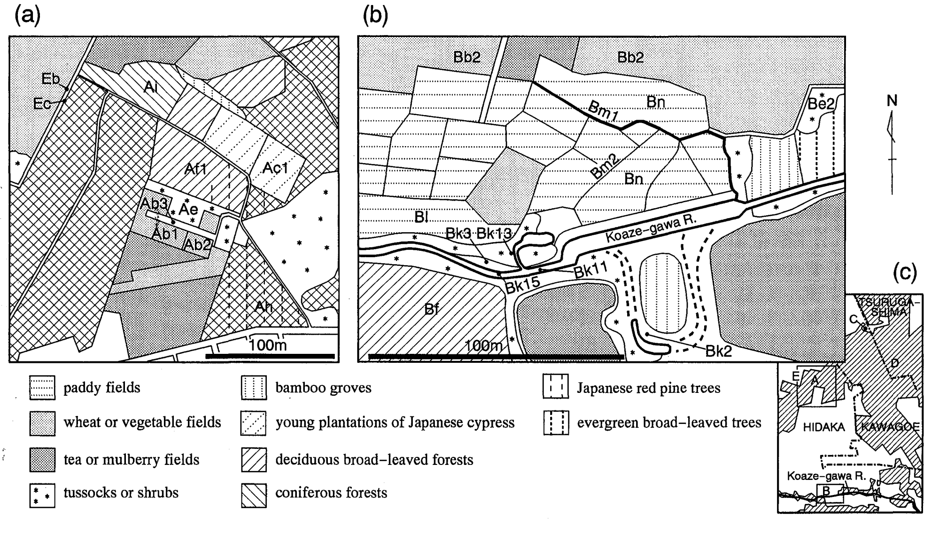

Fig. 1. Maps of the study area in 1984. Locations of Subarea A〜E (c); vegetation and 22 sampling sites in Subarea A, E (a), and B (b). The old course of Koaze-gawa River in Subarea B is indicated with broken lines (b, bottom). The other six sampling sites (Bh of Subarea B; Ca, Cb and Cf of Subarea C; Dh and Dm of Subarea D) are not shown here.

Table 1. Lycosid habitat classes and sampling sites.

Substrata	Light condition	Water condition		
		0: rain alone	*1:* standing water	*2:* running water
B: bare soil	*s:* sunshine	*Bs0:* Ab1, Bb2, Cb, Eb	*Bs1:* Bk2	*Bs2:* Bk11
L: live plants	*s:* sunshine	*Ls0:* Ab2, Ab3, Bk3	*Ls1:* Bl, Bm2, Bn	*Ls2:* Bk15, Bm1
D: dead plants	*s:* sunshine	*Ds0:* Ac1, Ae, Ca, Dh, Ec	*Ds1:* Be2	*Ds2:* Bk13, Dm
	d: dark or shade	*Dd0:* Af1,Ah,Ai,Bf,Bh,Cf	*Dd1:* —	*Dd2:* —

Italic abbreviations, the habitat classes; Roman ones, the sampling sites. There were no sampling sites in *Dd1* and *Dd2*. For characteristics and locations of these sampling sites, see the text and Fig. 1.

and Dm, edges of a tiny stream originating from a small spring in a tussock (Bk13) or a forest (Dm). The litter of Bk13 and Dm was usually soaked.

[Ah, Bh, Cf] Dark ground with thick litter. Ah and Bh, evergreen forests of white oaks, red pines, cedars, and cypresses with poor undergrowth; Cf, a deciduous forest of konara oaks with dwarf bamboos.

A hygrophyte, *Polygonum thunbergii*, dominated at Bl, while many herbaceous plants were found and seasonally alternated at every other site in open land. In winter, floors of deciduous forests were exposed to sunrays, and water was drained from paddy fields. But the classes of these habitats were decided by conditions in the other seasons because most lycosids retreated into litter or soil crevices in winter.

Methods

Sampling procedure

Hand-sort sampling was carried out 368 times on 233 calm days by 'time-sampling' or 'zone-sampling'. In each sampling by both methods, lycosids were individually driven into 15×100 mm glass tubes and then confined with cork plugs until 50$\sim$100 individuals were collected. Soaked cotton was previously placed at the bottom of the tubes to prevent the lycosids from drying.

In time-sampling, I walked at a slow constant pace and crouched down when capturing lycosids until the collection was attained, then recorded the total time of sampling for calculation of lycosid frequencies. When no lycosid was added for 10 or more minutes (this case was frequent in winter), the sampling was ended even before attaining of the collection. This sampling was employed as the main method 273 times (7,414 min.) in the daytime, and 13 times (507 min.) in the nighttime aided with a head lamp. These samples were called 'time-samples'.

In zone-sampling, I cautiously searched for lycosids from outer parts to inner parts within a 2$\sim$4 m^2 zone, and selected additional zones until the collection was attained, then recorded the total area of searching for the calculation. A $50 \times 50 \times 20$ cm aluminum quadrat was applied to sites with thick litter layers, and the area in the quadrat was regarded as the zone. At a site with low lycosid density, all the lycosids found in the site were collected. This method was employed 82 times (8,336 m^2) only in the daytime to obtain more precise frequencies and compare them with those in time-sampling. These samples were called 'zone-samples'.

At one or two fixed sites of every class except *Bs1* and *Ds1*, time-sampling was carried out almost monthly. At those of *Ls0*, *Ds0*, and *Dd0*, zone-sampling was also performed. Lycosids at the other sites were collected from March to November mainly by time-sampling.

Most of these lycosids were released at the center of each sampling site soon after examinations in the laboratory to minimize disturbance by sampling.

Categories in stages and sexes

Youngs, males, free females, females with egg cocoons, and females with pulli are used in this paper as categories of stages and sexes. Pulli on their mothers were not counted.

Measuring temperature

For an examination of difference in environmental conditions among the habitat classes, a maximum-minimum thermometer shaded with a $10\times25\times1.5$ cm plate of aluminum and styrofoam was held at 3 cm above the ground of each center of neibouring three sites, Ab2 of *Ls0*, Ae of *Ds0*, and Af1 of *Dd0*. These thermometers were read and reset weekly in 1986 and 1987. Temperatures of ground surfaces or water were also measured at the beginning and the end of every sampling.

Results

Of all 21,308 individuals collected by time- and zone-sampling, 12 individuals were those of unknown *Pardosa* species. Four species, *Arctosa fujiii*, *Pardosa agraria*, *P. astrigera*, and *P. graminea*, occupied 65% (10, 12, 25, and 18%, respectively) of the remnants. On the other hand, individuals of *Alopecosa virgata*, *Lycosa coelestis*, *Pardosa yaginumai*, *Tricca japonica*, and *Trochosa ruricola* were less than 0.5%. Percentage for each stage or sex was 74 in youngs, 8 in males, 10 in free females, 6 in females with egg cocoons, and 0.5 in females with pulli. Similar ratios were obtained in each species except 25～43% in youngs of *Arctosa depectinata*, *Pirata procurvus*, and *P. tanakai*, 18～19% in females with egg cocoons of the latter two species, and 0.09% in females with egg cocoons of *Arctosa fujiii*.

The 545 individuals in time-samples were collected at night mainly from Ab1 and Bb2. Their 50, 34, and 7% were *Arctosa depectinata*, *Pardosa astrigera*, and *P. graminea*, respectively. The percentage was lower in *P. graminea* but slightly higher in *P. astrigera* and remarkably higher in *A. depectinata* than that in the daytime. The 85%

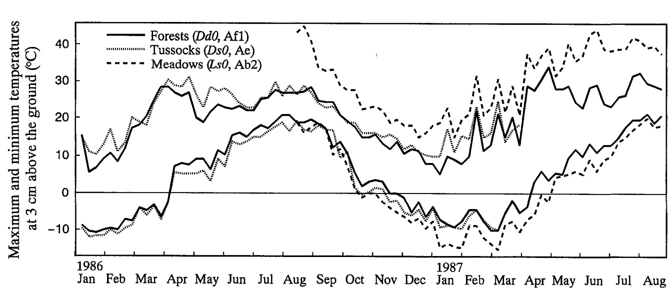

Fig. 2. Maximum and minimum temperature in a week at 3 cm above the ground in three contiguous sampling sites of different habitat classes, *Dd0*, *Ds0*, and *Ls0*.

of *A. depectinata* was found at night.

The weekly ranges of ground temperature in *Ls0*, *Ds0*, and *Dd0* were 46, 35, and 35°C at the maximum (February~April), 15, 7, and 6°C at the minimum (June~September), and 27.5, 18.8, and 15.6°C on the average, respectively (Fig. 2). Ground temperatures measured at sampling were 7~30°C in *Dd0*, whereas they were 6~41°C in the other classes. The highest temperature observed in running water was 26, 25, 24, and 14°C at Bm1, Bk11, Bk13, and Dm, respectively, while that in standing water was 28°C at B1 and 27°C at Bk2.

Differences between time-samples and zone-samples

All 19 species were found in time-samples of 15,319 individuals from 26 sampling sites of the 10 classes. Their frequencies in the number per h (f_t) were calculated in each sampling site (Table 2). In zone-samples of 5,989 individuals from 10 sites of the seven classes, the 17 species were found. Their frequencies in the number per 25 m^2 (f_z) were also calculated (Table 3). Ab2 and Ab3 were here treated as one site, since they neighbored on each other (Fig. 1a) and were classified into the same class of *Ls0*. The sites common to both of the samples were thus nine (the sites except Ae in Table 3). Rare two species, *Lycosa coelestis* and *Pardosa yaginumai*, did not occur in zone-samples.

In above two species and other four species, *Alopecosa virgata*, *Arctosa depectinata*, *Tricca japonica*, and *Trochosa ruricola*, the values of f_t and f_z did not exceed 1 and most of them were 0 at every nine sites. Therefore, the relationship between f_t and f_z was examined in the 117 pairs from the remnant 13 species of the nine sites, and significantly positive correlation ($r=0.624$, $P<0.001$) and a ratio of 0.241 for f_t/f_z were obtained. They did not largely change even after removing 63 pairs lower than 0.5 both in f_t and f_z ($r=0.574$, $P<0.001$, $f_t/f_z=0.209$). Furthermore, the highest f_t and f_z were observed at the same site in each 11 species. In four species of them, the coincidence occurred also in the second highest. Such coincidence was not obtained in *Pardosa graminea* and *Pirata tanakai*, but similar tendencies were observed.

Percentage for each stage or sex in time- and zone-samples was 71 and 84 in youngs, 10 and 5 in males, 12 and 7 in free females, 7 and 3 in females with egg cocoons, and 0.7 and 0.2 in females with pulli, respectively. They were similar in each category though youngs' percentage in time-samples was lower and the others' were higher than those in zone-samples.

Frequency in habitat classes

Difference among species

Lycosid frequency was compared between habitat classes except that of *Lycosa coelestis* with only one individual in each of *Bs0* and *Dd0* (Fig. 3). Frequency in a class was calculated not by averaging ones in the class but by the whole individuals and sampling quantity (in minutes or m^2) in the class.

The nine species of *Arctosa subamylacea*, *Pardosa agraria*, *P. pseudoannulata*, *P. yaginumai*, *Pirata clercki*, *P. piratoides*, *P. subpiraticus*, *P. yaginumai*, and *Tricca japonica* were found almost only in habitats around water (the upper nine in Fig. 3). *Arctosa subamylacea* and *Pirata piratoides* were frequent in *Bs1*, *Bs2*, *Ls1*, and *Ls2*, and *Pardosa agraria* showed high frequency in *Ls1*, *Ls2*, and *Ds1*. Classes with obviously high frequency were three or four in these three species, but were only two or one in the others. They were *Ls1* and *Ls2* in *Pardosa pseudoannulata*, *Bs1* and *Ls1* in *Pirata subpiraticus*, *Bs1* and *Bs2* in *Pirata yaginumai*, and *Ds2* in *Pirata clercki*.

Table 2. Lycosid frequency (n/h) in time-sampling sites.

Habitat class		*Bs0*				*Bs1*	*Bs2*	*Ls0*		*Ls1*			*Ls2*		*Ds0*				*Ds1*	*Ds2*		*Dd0*					
Sampling site		Ab1	Bb2	Cb	Eb	Bk2	Bk11	Ab2 Ab3	Bk3	Bl	Bm2	Bn	Bk15	Bm1	Ac1	Ca	Dh	Ec	Be2	Bk13	Dm	Af1	Ah	Ai	Bf	Bh	Cf
Sampling time (min)		756	473	39	110	31	421	1,106	31	598	55	952	25	827	659	110	260	48	41	218	87	930	14	64	11	17	38
	n	*912*	*779*	*23*	*181*	*99*	*866*	*2,246*	*29*	*1,466*	*118*	*1,663*	*47*	*2,110*	*1,621*	*79*	*489*	*60*	*93*	*350*	*93*	*1,730*	*20*	*96*	*26*	*50*	*73*
Alopecosa virgata	*2*	—	*	—	—	—	—	*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Arctosa depectinata	*320*	19	8	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Arctosa ebicha	*52*	1	—	—	—	—	—	*	—	—	—	—	—	—	1	—	—	—	—	—	1	2	—	—	—	—	—
Arctosa fujiii	*1,357*	*	1	3	—	—	3	1	8	*	—	1	34	1	9	8	17	10	—	4	9	62	60	6	22	—	104
Arctosa subamylacea	*274*	—	*	—	—	15	3	—	—	2	9	6	—	9	—	—	—	—	—	1	—	—	—	—	—	—	—
Lycosa coelestis	*2*	*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—
Pardosa agraria	*2,480*	—	3	—	—	—	6	—	14	18	68	66	17	77	—	—	—	—	63	2	—	—	—	—	—	—	—
Pardosa astrigera	*3,602*	48	82	12	98	—	*	102	—	1	—	9	2	6	1	6	—	30	—	—	—	1	—	2	16	—	—
Pardosa graminea	*2,322*	4	3	2	1	2	1	15	33	*	1	*	17	*	133	19	5	35	61	—	—	17	—	68	104	—	8
Pardosa pseudoannulata	*837*	*	*	18	—	2	2	—	—	37	10	10	7	18	—	9	—	—	—	2	—	*	—	—	—	—	—
Pardosa yaginumai	*6*	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pirata clercki	*396*	—	—	—	—	—	6	—	—	*	—	*	—	—	—	—	—	—	—	74	53	—	—	—	—	—	—
Pirata piratoides	*917*	—	1	—	—	23	11	*	2	11	21	11	2	37	—	—	—	—	—	4	—	—	—	—	—	—	—
Pirata procurvus	*309*	—	—	—	—	—	—	*	—	*	—	—	—	—	*	2	51	—	—	—	—	1	17	2	—	169	2
Pirata subpiraticus	*966*	—	—	—	—	35	6	—	—	77	17	3	—	6	—	—	—	—	—	2	—	—	—	—	—	—	—
Pirata tanakai	*699*	—	*	—	—	—	*	*	—	1	—	*	—	—	3	—	40	—	12	*	1	29	4	10	—	7	2
Pirata yaginumai	*706*	—	—	—	—	114	86	—	—	*	2	*	34	—	—	—	—	—	—	7	—	—	—	—	—	—	—
Tricca japonica	*9*	—	—	—	—	—	—	—	—	*	1	*	—	*	—	—	—	—	—	1	—	*	—	1	—	—	—
Trochosa ruricola	*55*	1	1	—	—	—	—	1	—	—	—	*	—	—	1	—	—	—	—	—	—	*	—	2	—	—	—
Unidentified lycosids	*8*	—	*	—	—	—	—	*	—	—	—	*	—	—	*	—	—	—	—	—	—	—	—	—	—	—	—
Total	*15,319*	72	99	35	99	192	123	122	56	147	129	105	113	153	148	43	113	75	136	96	64	112	86	90	142	176	115

Decimals of every value were rounded, and values of 0 and those smaller than 0.5 are represented by dashes and asterisks, respectively.

Table 3. Lycosid frequency ($n/25\ m^2$) in zone-sampling sites.

Habitat class		*Bs2*	*Ls0*	*Ls1*	*Ls2*	*Ds0*			*Ds2*		*Dd0*
Sampling site		Bk11	Ab2 Ab3	Bl	Bm1	Ac1	Ae	Dh	Bk13	Dm	Af1
Sampling area (m^2)		156	6,692	16	16	953	300	11	4	110	78
	n	*601*	*1,695*	*199*	*200*	*1,413*	*150*	*62*	*91*	*480*	*1,098*
Alopecosa virgata	*9*	—	*	—	—	—	—	—	—	—	—
Arctosa depectinata	*5*	—	*	—	—	*	—	—	—	—	—
Arctosa ebicha	*50*	—	—	—	—	*	—	—	—	—	15
Arctosa fujiii	*773*	—	*	—	—	4	*	2	31	5	183
Arctosa subamylacea	*56*	6	—	—	25	—	—	—	—	—	—
Lycosa coelestis	*0*	—	—	—	—	—	—	—	—	—	—
Pardosa agraria	*143*	1	—	2	207	—	—	—	6	—	—
Pardosa astrigera	*1,605*	—	5	—	2	*	11	—	—	—	—
Pardosa graminea	*1,597*	—	1	—	—	31	2	—	56	*	60
Pardosa pseudoannulata	*9*	—	—	12	2	—	—	—	—	—	—
Pardosa yaginumai	*0*	—	—	—	—	—	—	—	—	—	—
Pirata clercki	*566*	9	—	—	—	—	—	—	475	99	—
Pirata piratoides	*83*	5	*	—	64	—	—	—	—	—	—
Pirata procurvus	*42*	—	*	—	—	—	—	66	—	—	4
Pirata subpiraticus	*215*	3	—	289	12	—	—	—	—	*	—
Pirata tanakai	*377*	—	*	—	—	1	—	73	—	5	90
Pirata yaginumai	*442*	71	—	—	—	—	—	—	—	—	—
Tricca japonica	*1*	*	—	—	—	—	—	—	—	—	—
Trochosa ruricola	*12*	*	*	—	—	—	—	—	—	—	*
Unidentified lycosids	*4*	—	*	—	—	*	—	—	—	—	—
Total	*5,989*	96	6	311	313	37	13	141	569	109	352

Decimals of every value were rounded, and values of 0 and those smaller than 0.5 are represented by dashes and asterisks, respectively.

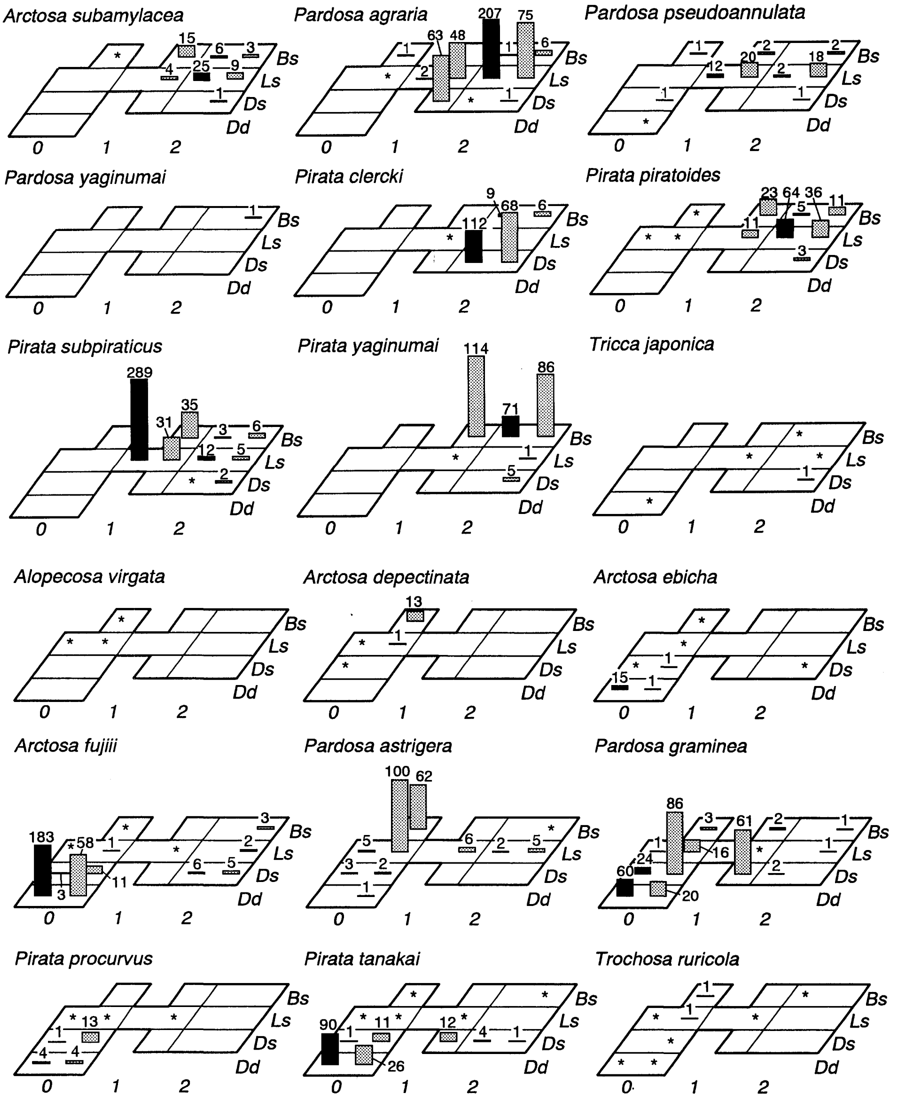

Fig. 3. Frequencies of the 18 lycosid species in each habitat class. The upper nine, species frequent in wet habitats; the lower nine, species frequent in dry habitats. Solid rectangles, frequencies in $n/25\ m^2$ (zone-samples); stippled ones, those in $n/$h (time-samples); asterisks, frequencies lower than 0.5 but not 0.

Pardosa yaginumai also concentrated on *Bs2* though it was very rare. *Tricca japonica* was also rare but occurred in various classes of wet habitats.

The remnant nine species, *Alopecosa virgata*, *Arctosa depectinata*, *A. ebicha*, *A. fujiii*, *Pardosa astrigera*, *P. graminea*, *Pirata procurvus*, *P. tanakai*, and *Trochosa ruricola*, were more frequent in drier habitats though *Alopecosa virgata*, *Arctosa ebicha*,

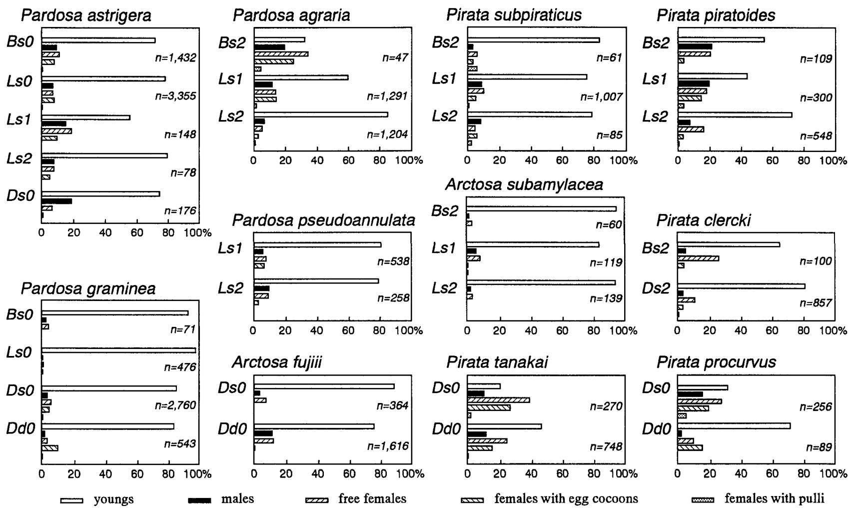

Fig. 4. Stage- or sex-composition of the 11 lycosid species in the habitat classes. The illustration is omitted for the other eight species, which had one or no class with 30 or more individuals.

and *Trochosa ruricola* were rare (the lower nine in Fig. 3). The classes with higher frequency were *Bs0* and *Ls0* in *Alopecosa virgata*, *Arctosa depectinata*, *Pardosa astrigera*, and *Trochosa ruricola*, *Ds0* or *Ds1* in *Pardosa graminea* and *Pirata procurvus*, and *Dd0* in *Arctosa ebicha*, *A. fujiii*, and *Pirata tanakai*.

Difference among stages or sexes

In order to detect stage- or sex-specific habitat selection, percentage for each stage or sex was calculated in samples of each habitat class (Fig. 4). Because the compositions in time- and zone-samples were similar to each other, the individuals from both samples were summed, and the percentages were calculated only in the classes where the sum reached to 30 or more. The calculation was omitted in eight species since the class was one or no.

Youngs of seven species, *Arctosa fujiii*, *A. subamylacea*, *Pardosa astrigera*, *P. graminea*, *P. pseudoannulata*, *Pirata clercki*, and *P. subpiraticus*, dominated others in every class. Adults of *Pardosa agraria* and *Pirata piratoides* increased their percentages in *Bs2* and *Ls1*. In *Pirata procurvus* and *P. tanakai*, percentage of youngs was generally low but youngs of the former were dominant in *Dd0*. However, these large changes were found mainly in classes with small individuals (*Bs2* with 47 *P. agraria* and *Dd0* with 89 *P. procurvus*).

Discussion

Usefulness of time-sampling

Trapping was effective in collecting small lycosids (*Pirata procurvus* and *P. tanakai*) at tussocks and forest floors with thick litter, or rare but active males (*Arctosa ebicha*, *Tricca japonica*, and *Trochosa ruricola*), but was not in collecting lycosids of

low-mobile species or stages (youngs and females with egg cocoons) (Fujii 1997). I observed in the laboratory that two *Arctosa* lycosids (*A. depectinata* and *A. subamylacea*) and two *Pirata* lycosids (*P. piratoides* and *P. subpiraticus*) made their nests below and above the soil surface, respectively, and seldom walked out of the nests. Hand-sorting collected these low-mobile lycosids especially in open habitats. Females with egg cocoons of the small *Pirata* species were easily found even in dark forests because their egg cocoons are white and conspicuous. Since females of *Arctosa ebicha* and *A. fujiii* do not carry their pulli (Fujii 1976, 1983) and the latter female retreats in an ovipositing room spun in litter, neither female with pulli could be found and the latter females with egg cocoons were seldom collected even by hand-sorting.

Zone-sampling gave more precise population density and composition of species or stages but demanded much more time than time-sampling, and it was hardly applicable to many sites. In time-sampling, time required for capturing one lycosid was only 5 seconds on the average, and that for 100 lycosids may be less than 20 minutes in high-density populations. Rough estimation of the density will be also possible by using f_t and f_t/f_z. In this study, 10 in f_t corresponded to 42 in f_z, thus to 2 per m^2. However, the ratios were remarkably higher at Ab2, Ab3, and Ac1. The much bare ground in these sites probably raised f_t and/or depressed f_z as lycosids on bare ground were easily found and captured but were not abundant.

Habitat classification

Though most species in one site occurred also in the others of the same class, the frequencies in several species were different among these sites probably because of differences in some qualities of soil or litter, or in distances from water. *Pirata yaginumai* occurred only on pebbly soil beside water (pebbles were rare around standing water but abundant at Bk2). *Arctosa depectinata* was found almost only on soft sandy soil. Immigrants of *Pardosa pseudoannulata* at Ca and Cb, which were both far from water, survived at least for two months because of puddles elongated by the clayey soil. *Pirata procurvus* and *P. tanakai* exhibited high frequencies at sites with litter containing red pine or cedar leaves. These leaves may raise survival rates of these small lycosids, offering them a lot of narrow retreat. *Pardosa agraria* and *Pirata piratoides* were generally rare in *Bs0* and *Ls0*, but many individuals were collected at Bb2 or Bk3 probably because both sites were located nearer to water than the others.

The habitat classification did not adequately correspond with above lycosid frequencies because of its simplicity, but it may be very convenient and useful to examine the difference between lycosid habitat preferences.

Habitat preference

In habitats with an unfavorable or intolerable condition, lycosids probably show extremely low frequency in all of the trap-, time-, and zone-samples, and in the others, they may show high or moderate frequency in any of these samples. Thus, preferable or tolerable habitats of the lycosids in the study area may be as follows (Fig. 5).

[Sunny open habitats] *Bs0*; *Arctosa depectinata*: *Bs0-Ls0*; *Alopecosa virgata*: *Ls1*; *Pirata subpiraticus*: *Bs2*; *Pardosa yaginumai*: *Ls1-Ls2*; *Pardosa pseudoannulata*: *Bs2-Ls2*; *Pirata yaginumai* (Bk2 was treated here as a river edge): *Bs1-Bs2-Ls1-Ls2*; *Arctosa subamylacea*, *Pirata piratoides*: all of these classes; *Pardosa astrigera*.

[Forest floors or their edges] *Ds2*; *Pirata clercki*: *Ds0-Ds1-Ds2-Dd0-Dd1-Dd2*; *Arctosa ebicha*, *A. fujiii*, *Pardosa graminea*, *Pirata procurvus*, *P. tanakai*.

[Ecotones between meadows and forests] *Ls0-Ls1-Ds0-Ds1*; *Trochosa ruricola*: *Ls1-*

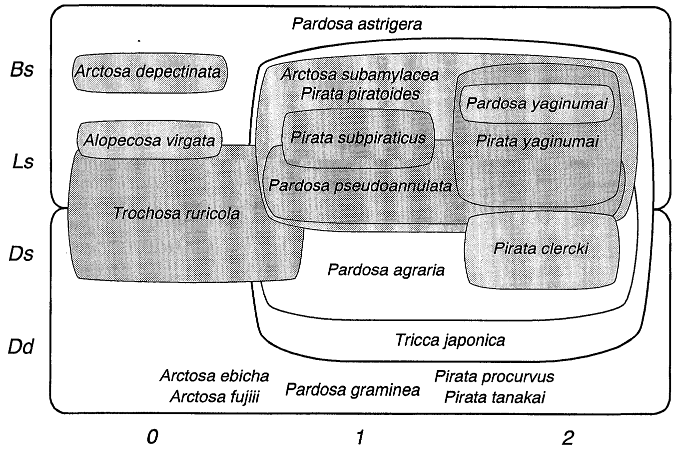

Fig. 5. The 18 lycosid species' habitat preferences inferred from frequencies in both of trap-samples (Fujii 1997) and hand-samples (Fig. 3). One rare species, *Lycosa coelestis*, is omitted here.

Ls2-Ds1-Ds2; *Pardosa agraria.*

Lycosa coelestis can be included in the last group from description by Miyashita (1997) and my other observations. *Tricca japonica* probably prefers wet habitats regardless of the openness.

Difference in the habitat preference was little among stages (thus little among seasons), while generally large among species of the same genus. However, the difference between *Arctosa ebicha* and *A. fujiii* and between *Pirata procurvus* and *P. tanakai* is probably little. The latter two species were similar in the body size and breeding season, and when one species was frequent, the other was not at every site in *Dd0* (Table 2). This suggests the interspecific competition between them. Partial overlap of the preferences was also detected between *Pirata piratoides* and *P. subpiraticus* or *P. yaginumai*, and between *Pardosa agraria* and *P. astrigera* or *P. graminea* (Fig. 5). *P. agraria* is usually found around water (Yamano 1985, Matsuda & Shibata 1995) but occurs also in drier meadows and forest edges (Suwa 1986). *Pardosa* of the latter two habitats in the study area was not *P. agraria* but *P. astrigera* or *P. graminea.* Some interspecific interference might be expected especially between closely related species, *P. agraria* and *P. graminea.*

Stability and mildness in the habitats

The temperature conditions of *Ls0* were harder than those of *Ds0* and *Dd0* (Fig. 2). The fluctuation of temperature in *Bs0* was certainly much larger than that in *Ls0*. The environmental conditions around standing water seem to be unstable since the water disappeared often in autumn and winter, whereas most running water existed throughout all seasons and its highest temperature was low.

Predation pressure by vertebrates is probably hard in every sunny open habitat. Flocks of starlings or sparrows often visited the meadows. Many frogs inhabited in the paddy fields. Wagtailes were foraging along the open stream edges. On the other hand, pheasants, lizards, or toads were found on the tussock or forest floors, but they

were very rare except lizards. Furthermore, *Bs0*, *Bs1*, *Ls0* and *Ls1* in the study area were kept by plowing or mowing. Some sites of these classes rapidly returned to tussocks after farming was abandoned. From these observations or inference, the stability and mildness may be high in *Dd0*, *Dd2*, *Ds0*, and *Ds2*, and low in *Bs0*, *Bs1*, *Ls0*, and *Ls1*.

The nine species in sunny open habitats may be adapted to hard and/or unstable conditions. Above all, *Pardosa astrigera* occurred almost all open sites. *Arctosa depectinata* also succeeded in dwelling in the hardest habitats of *Bs0* by its daytime retreating into soil. Contrary, the six species in forest floors or their edges may be adapted to the most stable and mild habitats.

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摘　　要

関東平野北西部でハンドソーティングにより 19 種のコモリグモ(クモ目：コモリグモ科）を採集し，3 つの環境要素（底質，光，水）で分類した生活場所における頻度から，それぞれの生活場所選好性を推定した．ハンドソーティングにより，落し穴トラップで調査された 12 種（Fujii 1997）に加えて 7 種（スジブト，カガリビ，クロコ，ハラクロ，キクヅキ，キシベ，キバラ）が検討できるようになり，イナダハリゲ，ウヅキ，クラーク，イモではより正確な選好性を知ることができた．種間の相違はそれぞれの属内で大きかったが，エビチャとフジイ，チビとコガタには見られなかった．他のオオアシコモリグモ属やカイゾクコモリグモ属の数は，選好性の部分的重複も認められた．ステージ間の相違は不明瞭であった．

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